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TIMBER STRESS GRADING:
*EVALUATION OF RESPONSES TO QUESTIONNAIRE ON TIMBER STRESS GRADING AND STRENGTH GROUPING RESEARCH AND DEVELOPMENT ACTIVITIES**

Prepared by

Timber Research and Development Association**

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** High Wycombe, United Kingdom.

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INTRODUCTION

An outcome of an Expert Group Meeting on Timber Stress Grading and Strength Grouping held in Vienna, from 14 to 17 December 1981 was the circulation of a questionnaire on research and development activities within this field. The purpose was to gather information on current projects of this type in which forest products laboratories, research associations, universities, trade associations and other bodies are involved. The objectives of the projects revealed by the questionnaire would be identified, technical details summarized, and further information on codes and standards would be given.

The results of the questionnaire would be evaluated by an organization briefed by UNIDO to draw up a standard framework for stress grading rules for developing countries. The organization would also be required further to consult with earlier participants and new contacts.

This report provides the evaluation, carried out by the Timber Research and Development Association (TRADA) in 1983/84 in accordance with these terms of reference.

FORMAT OF QUESTIONNAIRE

The actual form of the questionnaire which was circulated is shown in Annex I of this document, and the responses to the questionnaire in Annex II. It is hoped that much of the questionnaire is self-explanatory, certainly the quality and quantity of replies received was impressive. Although the section on Building Standards was intended for developing countries only, many of the replies from industrialized countries also gave useful information on these. The final 'catch-all' question -'Have we asked the right questions' - gave scope for some respondents to fill the gaps.

RESUME OF REPLIES

In the following resumes, initials or brief titles of responding organizations are cross-referred by number to the full list given in Annex II.

CURRENT PROJECTS, OBJECTIVES AND FURTHER DETAILS

CTIB(1) report research on spruce (Picea excelsa) grown in Belgium. They are studying the relation between anatomic characteristics, structural defects and mechanical properties. The first steps will entail visual grading, but mechanical and other more sophisticated methods will follow. Their objectives are to develop a set of grading rules for Belgian softwoods and to improve the use of timber through closer relations between grading and end purpose.

This is a two to four year project, commencing in the latter part of 1982 and involving 4 or 5 people.

The University of Toronto (2) replied with details of two projects. One, a two man-year project, concerns the tensile strength and stiffness of poplar woods in structural sizes, whilst the other concerns the use of tropical hardwoods in the Andean Pact group of countries. The project aimed at developing models for tensile strength and stiffness of temperate hardwoods is intended to influence future visual and mechanical rules for these, with special reference to their possible use in laminated beams. In the South American project, correlations between strength, stiffness and grade-permitted defects are being examined, special emphasis being placed on the need to sort heterogeneous tropical hardwoods into stiffness categories.

The Forest Products Laboratory, Finland (5), is continuing work on approval of the Finnograder stress grading machine. Grade stresses are to correspond with those of existing visual grades and the machine will possibly grade to BS 4978 or other relevant standards.

The Forest Products Department of the Institute for Industrial Research and Standards (Ireland)(6) reports three projects. One is accumulating a data bank on the strength properties of Irish timber, objectives being the establishment of permissible design stresses and evolution of a viable grading system. (Start: 1979, End: 1985, Manpower: 1 Professional and 1 Technician per annum.)

The second project is attempting to develop an inexpensive small output mechanical grader suitable for sawmills, merchants and manufacturers in Ireland. (Start: 1982, End: 1982, Manpower: 2 Professionals and 4 technicians.)

The third is a project involving machine grading and the derivation of design stresses for scaffold boards.

In addition to these projects a number of quality control programmes are being successfully operated.

The Technical University of Munich (4) is cooperating in a national research programme entitled, 'Structural safety and reliability, development of probability-based safety concepts'. This involves the effect of stress grading and strength grouping on the reliability of glulam components. A research proposal entitled, 'Optimization of stress grading including the number of strength classes and grade units' has also been submitted to the Commission of European Communities. Results are intended to be applied to visual and mechanical grading of glulam laminations.

The Institute of Applied Science and Technology (Nigeria) (10) reports a sawmill project where grading forms part of the wider objectives of improving sawmill performance. Results will be applicable to visual grading and special use material. (Start: 1981, End: 1983, Manpower: 3 men.)

The Italian Federation of Wood, Cork, Furniture and Furnishing Industries (8) indicates that it has no specific projects underway but aims to introduce and experiment with the FAO/ECE stress-grading standard.

At the Warsaw Agricultural University (12) recent projects have included research into the mechanical properties of visual stress-graded

coniferous sawn timber for structural use in Poland, and visual and mechanical methods of stress grading timber in small sizes (18 to 32 mm thick) for structural use. They are also currently conducting projects on visual methods of stress grading coniferous sawn timber thicker than 100 mm and on mechanical methods of stress grading coniferous sawn timber less than 25 mm thick and 100mm wide. These projects partly include the physical principles of mechanical grading, eg. sonic methods and hardness based methods.

The Royal Institute of Technology (Sweden) (14) currently has three projects underway. One is investigating tolerances in practical grading (visual and by machine), their influence on permissible stresses and relation to grading conditions, whilst others consider the international unification of stress grading rules and grading rules for special uses such as glulam.

Colorado State University (15) reports two relevant projects. The first is attempting to develop a reliability-based design procedure for wood transmission structures, whilst the second is endeavouring to predict the tensile strength of wood containing defects such as cross-grain, knots and checks by developing a suitable mathematical model.

The Forest Research Institute (New Zealand) (18) currently has two projects under way on grading. The first is evaluating visually graded Radiata Pine via the 'in-grade' approach developed by Borg Madsen. A report is anticipated in June 1983. The second is evaluating proof testing as a grading method. (End: December 1983, Manpower: 1 man year.)

Finally, the Wood Technology Institute (Poland) (16) has a series of projects underway, both of a fundamental and applied nature. These have the objective of implementing mechanical strength grading of sawn timber in Poland and securing an international certificate for a mechanical sorter of the ITD-DKT-3 type developed at the Institute. It is also hoped that this work will create a basis for changes in Polish standards PN-82/D-94021 and PN-81/D-03150. The Institute is also cooperating in an EEC and Finland project 'Strength indices of construction sawn timber, effect of defects on these indices and mechanical strength classification of sawn timber'.

BUILDING STANDARDS

Replies relating to building standards were received from various countries (not only developing countries). For completeness all such replies received are included.

CTIB (Belgium) (1) states that in Belgium a limited number of technical specifications covering the structural use of timber exist and these are applied only on a contractual basis.

A new edition of the Danish Code of Practice on the structural use of timber is in print. Formulated on the strength grouping concept, it utilizes four of the groups mentioned in the CIB-W18 structural timber design code (Danish Building Research Institute) (3).

The Technical University of Munich (4) list three relevant German standards:

- DIN 1052 Timber structures, design and construction;
- DIN 1074 Timber bridges, design and construction;
- DIN 4074 Building timber for wood building components, quality conditions for converted building timber (softwood).

Such German DIN standards are usually used in Italy, although the FAO/ECE standard concerning stress grading has recently been adopted as a national standard there. (Italian Federation of wood, cork, furniture and furnishing industries) (8). Building Research Station (Israel) (7) indicates that no standards exist for the use of timber in structures or for stress grading in Israel. All its structural timber is imported and is selected for use by craftsmen. A formwork code does exist which refers to timber.

Delft Technical University (Holland)(9) states that the Dutch building standard NEN 3852: Timber Structures is currently being revised to a probabilistic basis.

Information on the various Polish standards was provided by Warsaw Agricultural University (12), Building Joinery Research and Development Centre (13) and Wood Technology Institute (16). These are as follows:

- *Polish standard PN-82/0-94021: Stress graded coniferous sawn timber for structural use (25-100 mm thick);*
- *Polish Standard PN-81/0-03150: Timber structures. Design rules. (Design based on limit states as partial safety factor for loads and materials.)*

The Canadian building standard CSA 086: Code and Engineering Design in wood is currently being revised and will appear in 1983 in a limit state design format. Timber frame houses do not have to be designed to this code but rather to Part 9 of the National Building Code of Canada - a prescriptive code including span tables, etc.: (Council of Forest Industries of British Columbia - Canada) (17).

The Institute of Applied Science and Technology (Nigeria)(10) states that building standard NCP 23: The Use of Wood In Building Construction is used in their country. This is formulated on a deterministic basis.

The Forest Research Institute of New Zealand states that two building standards are in operation. The standard for light frame timber construction (NZS 3604) is a descriptive code based on deterministic principles, whilst the standard for structural timber design (NZS 3603) is formulated on a deterministic basis. Although the possibility of revising this code to a limit state design format has been discussed no real enthusiasm seems to exist at present.

Finally, the Norwegian Technial Institute (4) indicates that stress grading standard NS 3080 is used in Norway.

OTHER COMMENTS

The final part of the questionnaire was an 'open-ended' question which invited additional questions or comments to be made about the relevance and content of the questionnaire. These comments are summarized below:

Mr. Saarelainen (5) stated that a system which relates 5 percentiles for a series of grading rules from structural tests

to small clear specimen values would be both simple and efficient for a limited number of species. However, since the small clear approach can be used for guidance only, if there are many species groups and visual grades of these a stress classification system might be convenient.

UNIDO was cautioned by Prof. Keenan (2) to review the findings of the Andean Pact workers before becoming committed to developing strength related grading rules for tropical hardwoods. Earlier he stated that it was likely that grading rules for tropical hardwoods should relate primarily to stiffness and secondly to strength.

Dr.-Ing. Glos (4) stresses the importance of investigating the scientific background of stress grading and strength grouping in addition to technical and commercial aspects based on presently used grading principles. He states that there is some evidence that better predictors or combinations of predictors are available than those used at present.

Prof. Kuipers (9) was unclear as to what the questionnaire wanted to know. He also raised the question, 'What is going to happen in Europe with the ECE grades? Will they be used and by which countries?'. He would also like to know the definite strength - not allowable strength characteristics. A better relationship with CIB-W18 was recommended.

Prof. Madsen (19) feels that it is extremely important to grade so that the proposed ISO system of strength grades will be followed. He states that grading rules should be developed to obtain the stresses in the proposed strength classification system.

Finally, Prof. Dr. Babicki (16) raises the question, 'Why does mechanical strength grading of sawn timber not find its proper place with sawn timber producers and users?' He feels that one of the reasons is the divergence of results from different authors investigating a relationship between modulus of elasticity and strength. He states that the solution of these problems is the responsibility of science.

REFERENCES

The reference numbers (1) to (19) mentioned in the text correspond to the numbers in the questionnaire in which the following references were provided:

Glos, P. and Heimeshoff, B. (1982): Capabilities and limitations of stress grading of laminae for glulam structures (in German). Ingenieurholzbau in Forschung und Praxis., Ed.: J. Ehlbeck and G. Steck, Karlsruhe: Bruderverlag 1982, pp.41-47.

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Bodig, J. and Troxell, H.E., (1965): Mechanical Stress-rating of Engelmann Spruce, Colorado State University Agricultural Experiment Station General Series 822, 48 pp.

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ANNEX I

QUESTIONNAIRE ON STRESS GRADING AND STRENGTH GROUPING RESEARCH AND DEVELOPMENT ACTIVITIES

Please feel free to interpret the following questions as you think appropriate and give such additional information as you think may be of benefit, attaching reports and unpublished information to the answer sheets as necessary.

(1) TITLES, ADDRESS

As well as ensuring that we have the correct title and address of your organization and names of persons concerned with stress grading and strength grouping projects, please give details of any organizations with whom you are collaborating. Indicate any international liaisons which you have already formed and the extent to which the work is being shared.

(2) PROJECTS CURRENT

What are your projects? Please give titles or very brief descriptions of current or recent projects on stress grading or strength grouping, with which you are concerned. Indicate start date, duration and effort, eg. in terms of man-years, if possible.

(3) OBJECTIVES OF PROJECTS

What are their objectives? Indicate whether for example the work is aimed at replacing or improving existing grading rules; introducing rules for the first time; or changing current grading concepts completely. Are the grading rules intended for implementation in your own country or internationally? In either case please give references to relevant standards, codes of practice or regulations. Give similar information, if relevant, on work on strength groups.

(4) FURTHER TECHNICAL DETAILS

Please give us further details. Do your stress grading projects include work of a fundamental nature? Will the results be applied in:

visual grading?

mechanical grading?

special use material, eg. scaffold boards?

(5) BUILDING STANDARDS (Developing Countries only)

What building standards or codes of practice are now in effect which cover the structural use of timber in construction? Are they deterministic or based on limit state design (or partial safety factors)? Are they being or will they be revised to a probabilistic basis?

In your view are they now biased against the use of timber as a structural material? Briefly, how?

(6) REFERENCES

Unless already covered above, please give references to relevant publications, reports, technical notes, proceedings, etc.

(7) HAVE WE ASKED THE RIGHT QUESTIONS?

It is very difficult in compiling a questionnaire on such a broad and technical subject to foresee what information will be the most useful, and we should welcome comments, additional notes, information about the work of others, etc.

ANNEX II

RESPONSES TO QUESTIONNAIRE

1. NAME AND ADDRESS OF ORGANIZATION

Mr. E. Sauvage
Centre Technique de l'Industrie du Bois
Chaussee d'Alsemberg 830
1180 Bruxelles
Belgium

COLLABORATING ORGANIZATIONS

- *I. W. O. N. L., De Crayerstraat 6, Brussels*
- *Prof. J. Schalck, Rijks Universiteit Gent*
- *Mr. E. Clicheroux, Administrateur des Eaux et Forêts*
- *Grecon, Hannover, Federal Republic of Germany*

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

- *Research on home grown spruce (Picea excelsa)*
- *Relation between anatomic characteristics, structural defects and mechanical properties.*
- *Start: End 82 for 2-4 years (4 to 5 men).*

3. OBJECTIVES OF PROJECTS

Try to develop a set of grading rules for Belgian softwoods. Aim to optimize the use of timber through closer relation between grading and usage. (Implementation basically related to Belgium.)

4. FURTHER TECHNICAL DETAILS

Fundamental work with visual grading a first step, leading to mechanical grading and possibly more sophisticated methods. Interest in the industrial production of timber construction prefabricated houses, glulam beams.

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

Some technical specifications in Belgium covering structural use of timber. These are applied only on a contractual basis. Cover roof construction, floors, windows, doors, etc.

6. REFERENCES

Not yet available.

7. OTHER QUESTIONS

None.

1. NAME AND ADDRESS OF ORGANIZATION

Prof. F. J. Keenan
University of Toronto
203 College Street
Toronto, Ontario, M55 1A1
Canada

COLLABORATING ORGANIZATIONS

- *Andean Group countries of South America*
- *International Development Research Centre, Ottawa, Canada*
- *Deptartment of Forest Products, Kasetsart University Thailand*
- *Division of Structural Engineering - Asian Institute of Techology, Thailand*
- *Standards & Industrial Research Institute of Malaysia*
- *Faculty of Forestry, University Pertanian Malaysia*
- *Ministry of Energy and Mines - Government of Costa Rica*
- *Institute of Standards and Industrial Research - Paraguay*

2 CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

(a) *Tensile strength and stiffness of poplar lumber (2 man years)*

(b) *Utilization of tropical hardwoods as building materials in the Andean group countries of South America. Publications likely to be ready in 1983.*

(c) *Other projects: Currently developing projects in this field in Malaysia, Thailand, Paraguay, Bolivia and Canada.*

3. OBJECTIVES OF PROJECTS

(a) *Develop models for tensile strength and stiffness*

(b) *Study correlation between strength stiffness and grade permitted defects for tropical hardwoods*

4. FURTHER TECHNICAL DETAILS

(a) *Results will influence visual and mechanial grading rules for hardwoods to be used as laminating stock for glulam beams. (Applicable to CSA glulam standards and relevant to structural use of hardwoods internationally.)*

(b) *Likely that grading rules for tropical hardwoods should relate primarily to stiffness and secondly to strength.*

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

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6. REFERENCES

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7. OTHER QUESTIONS

Re question 3(b): UNIDO is advised to review the findings of the Andean pact workers before becoming committed to developing strength-related grading rules for tropical hardwoods.

1. NAME AND ADDRESS OF ORGANIZATION

Prof. H. J. Larsen
Danish Building Research Institute
SBI Postboks 119
DK-2970 Horsholm
Denmark

COLLABORATING ORGANIZATIONS

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2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

As Chairman of ISO/TC165 involved with Dr. Leicester's project. No activities regarding stress grading, etc. at Danish Building Research Institute.

3. OBJECTIVES OF PROJECT

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4. FURTHER TECHNICAL DETAILS

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5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

New edition of Danish Code of Practice on structural use of timber in print. Formulated on the strength grouping concept. Only 4 of the groups mentioned in CIB-W18 Structural Timber Design Code are included.

6. REFERENCES

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7. OTHER QUESTIONS

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1. NAME AND ADDRESS OF ORGANIZATION

Prof. Dr. Ing. Peter Glos
Lehtstuhl und Institut fuer Holzforschung der Universitaet Muenchen
Winzererstrasse 45
8000 Muenchen 40
Federal Republic of Germany

COLLABORATING ORGANIZATIONS

Contacts with most of the leading research institutions.

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

(a) *Co-operation in national research programme structural safety and reliability, development of probability based safety concepts. Involving the effect of stress grading and grouping on the reliability of glulam components (continuing to end 1984 - 2 man years/year).*

(b) *Optimization of stress grading including the number of strength classes and grade limits. Research proposal submitted to CEC.*

3. OBJECTIVES OF PROJECT

(b) *Better utilization of the quality of home grown timber - to select and use high quality material more efficiently and to increase the amount of available structural timber by increasing the yield within structural grades by developing and applying a more efficient stress grading method.*

4. FURTHER TECHNICAL DETAILS

(b) *The results are intended to be applied to visual and mechanial grading of glulam laminations.*

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

- *DIN 1052 Timber Structures, design and construction.*
- *DIN 1074 Timber bridges, design and construction.*
- *DIN 4074 Building timber for wood building components, quality conditions for converted building timber (softwood).*

6. REFERENCES

- *Glos, P. and Heimeshoff B. (1982): Capabilities and limitations of stress grading laminae for glulam structures (in German).*
- *Glos, P. and Th. Michel (1982): The strength distribution of timber as dependent on stress grading efficiency (Paper presented to IUFRO, Boras, Sweden).*
- *Glos, P. (1982): Machine stress grading of sawn lumber. State of the art - comparison of different methods (in German). Holz-Zentralblatt 108, 153-155.*
- *Glos, P. & Schultz H. (1980): State of the art and prospects for machine stress grading (in German). Holz als Roh- und Werkstoff, 38, 409-417.*

7. OTHER QUESTIONS

Important to investigate the scientific background of stress grading and strength grouping in addition to technical and commercial aspects based on presently used grading principles. There is some evidence that there are better predictors (or combinations of predictors) available than those used at present.

1. NAME AND ADDRESS OF ORGANIZATION

Mr. Urho Saarelainen
Research Officer
Technical Research Centre of Finland
Forest Products Laboratory
SF-02150 Espoo 15
Finland

COLLABORATING ORGANIZATIONS

Mr. J. Kangas
Mr. E. Pennala
Mr. A. Raveala - Finnish Sawmill Owners Association
Fabianinkatu 29C
SF-00100 Helsinki 10
Finland

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

Approval of stress grading machine Finnograder. Started 1978 with the prototype. Continued in 1979 with MK II. Total efforts 2 man-years.

3. OBJECTIVES OF PROJECTS

(1) Verifying machine parameters - repeatability, consistency, etc.
(2) Correlation of machine parameters with stress values.
(3) Formulation of stress prediction model - grade stresses to correspond to those of existing visual grades, possibility to grade BS 4978 or other relevant grades.
(4) Strength groups not applicable as such - machines grade to target stress.

4. FURTHER TECHNICAL DETAILS.

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5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

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6. REFERENCES

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7. OTHER QUESTIONS

A system which relates 5 percentiles for a series of grading rules from structural tests to small clear specimen values would be simple and efficient for a limited number of species. However, since the small clear approach can be used for guidance only, if there are many species groups and visual grades then a stress classification system might be convenient.

1. NAME AND ADDRESS OF ORGANIZATION

Mr. P. R. Colclough - Head, Forest Products Department
Institute for Industrial Research and Standards
Ballymun Road
Dublin 9
Republic of Ireland

COLLABORATING ORGANIZATIONS

- *Princes Risborough Laboratory (UK) - (Curry/Tory/Fewell)*
- *Forest Products Laboratory Madison, USA (Calligan/Greene/Murphy/Gerhardts)*
- *University of British Columbia, Canada (Prof. Madsen)*
- *Forest Products Laboratory, Sweden (Dr. B. Noren)*
- *National Timber Research Institute, South Africa (Bryant)*
- *CSIRO, Australia (Dr. Leicester)*
- *Forest Research Institute, New Zealand (B. Walford)*
- *Centre Technique du Bois, France (Crubile)*
- *Houtinstituut TNO, Holland (A Van der Velden)*
- *Technical Research Centre, Finland (Saarelainen)*

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

(a) *Data bank on strength properties of Irish Timber. Objective to establish permissible design stresses, and evolve a viable grading system. Start: 1979; End: 1985; Manpower - 1 professional and 1 technician per annum.*

(b) *Objective to develop an inexpensive small output mechanical grader for sawmills, merchants and manufacturers in Ireland. It would be a one grade machine, i.e. yes/no. Start: 1982; End: 1983; Manpower - 2 professional and 4 technicians.*

(c) *Scaffold Boards. Project commencing involving machine grading and derivation of design stresses for scaffold boards.*

3. OBJECTIVES OF PROJECTS

See 2. above.

4. FURTHER TECHNICAL DETAILS

Quality control programmes successfully operated in:

(1) *Timber in housing - monitoring of wood and wood products in new housing.*

(2) *Roof trusses.*

(3) *Visual stress grading - monitoring and training.*

(4) *Machine stress grading - monitoring of approved mechanical stress grading machines.*

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

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6. REFERENCES

--

7. OHTER QUESTIONS

Because of its special characteristics e.g. fast growth, visual grading to BS 4978 gives poor yields for Irish Timber. Studies have shown mechanical grading is much more satisfactory.

1. NAME AND ADDRESS OF ORGANIZATION

Dr. U. Korin
Head of Testing Department
Building Research Station
Technion Research & Development Foundation
Haifa 32000
Israel

COLLABORATING ORGANIZATIONS

Israeli Standard Institution
40 University Street
Tel Aviv
Israel

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

None.

3. OBJECTIVES OF PROJECTS

--

4. FURTHER TECHNICAL DETAILS

At the moment there is no stress grading practice in Israel and timber for structural purposes is selected by craftsmen.

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

No standards for the use of timber for structures for stress grading. There is a formwork code which refers to timber.

6. REFERENCES

--

7. OTHER QUESTIONS

Israel imports all its structural timber.

1. NAME AND ADDRESS OF ORGANIZATION

Mr. G. U. Marchi
Federazione Italiana Industria del Legno (Federlegno)
S Felice VII/24
I-20090 Segrate Milan
Italy

COLLABORATING ORGANIZATIONS

Federlegno-Arredo
Via Mascheroni 19
I-20145 Milan
Italy

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

None.

3. OBJECTIVES OF PROJECTS

Aim is to introduce and experiment with the FAO/ECE stress grading standard.

4. FURTHER TECHNICAL DETAILS

Stress grading regulations will be used for visual grading and for calculations in timber structures and glulam.

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

Have adopted the FAO/ECE Standard concerning the stress grading as a national standard (Normal UNI). Usually use DIN standard from German practice.

6. REFERENCES

--

7. OTHER QUESTIONS

--

1. NAME AND ADDRESS OF ORGANIZATION

Prof. J. Kuipers
Department of Civil Engineering
Delft University of Technology
P. O. Box 5048
2600 GA, Delft
Netherlands

COLLABORATING ORGANIZATIONS

Stichting Centrum Hout
(Onderzoekcommissie OC19)
Lambertus Hortensiuslaan 76
1412 GX Naarden
Netherlands

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

None.

3. OBJECTIVES OF PROJECTS

--

4. FURTHER TECHNICAL DETAILS

--

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

New 3852 Timber Structures is in revision to a probabilistic basis.

6. REFERENCES

--

7. OTHER QUESTIONS

Not clear what you want to know. What is going to happen in Europe with the ECE-grades? Will they be used and by which countries?

What are the definite strength - not allowable strength characteristics?

A better relationship with CIB-WIB is recommended.

1. NAME AND ADDRESS OF ORGANIZATION

Mr. E. E. Lucas
Institute of Applied Science and Technology
University of Ibadan
Nigeria

COLLABORATING ORGANIZATIONS
Forest Products Research Laboratory, Nigeria

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

Sawmill project - Production quality studies. Start 1981; End: 1983; three men.

3. OBJECTIVES OF PROJECT

Grading is only part of this. Wider objectives are to improve sawmill performances.

4. FURTHER TECHNICAL DETAILS

Results applied to visual grading and special use material.

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

NEP2: The use of wood in building construction. This is on a deterministic basis and will not be revised to a probabilistic basis yet.

It is meant to remove the bias against the structural use of timber.

6. REFERENCES

--

7. OTHER QUESTIONS

Yes, I think you have asked the right questions.

1. NAME AND ADDRESS OF ORGANIZATION

Mr. K. Morkved
Norsk Treteknisk Institutt
Box 337
Blindern
Oslo 3
Norway

COLLABORATING ORGANIZATIONS
The Swedish Wood Research Institute
The Technical Research Centre, Finland

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

None.

3. OBJECTIVES OF PROJECTS

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4. FURTHER TECHNICAL DETAILS

Mechanical grading is prepared for but not being used yet.

5. BUILDING STANDARDS (DEVELOPNG COUNTRIES ONLY)

Stress grading standard in use is NS 3080.

6. REFERENCES

--

7. OTHER QUESTIONS

--

1. NAME AND ADDRESS OF ORGANIZATION

Dr. W. S. Dzbenski
Expert on Woodworking Industries
Warsaw Agricultural University
Faculty of Wood Technology
Ul. Rakowiecka 26/30
02-528 Warsaw
Poland

COLLABORATING ORGANIZATIONS

Institute of Wood Technology, Poland
Research and Development Centre of Timber Industry, Poland
Polish Stress Grading Committee of ECE/UN Geneva

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

Recent Projects:

(a) Mechanical properties of visual stress graded coniferous sawn timber for structural use in Poland.

(b) Visual and mechanical method of stress grading timber in small sizes (19-32 mm thick) for structural use.

Current projects:

(a) Visual methods of stress grading of coniferous sawn timber more than 100 mm thick.

(b) Mechanical methods of stress grading of coniferous sawn timber less than 25 mm thick and 100 mm wide.

3. OBJECTIVES OF PROJECTS

See 2 above.

4. FURTHER TECHNICAL DETAILS

These projects partly include physical principles of mechanical grading, e.g. sonic methods and hardness based methods. We do not specify detailed use of timber.

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

Polish standard PN-82/D-94021 stress graded coniferous sawn timber for structural use (25-100 mm thick).

6. REFERENCES

Dzbenski, W: Mechanical methods of lumber stress grading in Poland (in Polish).

Dzbenski, W.: Testing methods of structural timber quality (in Polish).

Dzbenski, W.: Attempts at implementing ultrasonic measurement technique in stress grading of structural timber (in German).

12 References included in total.

7. OTHER QUESTIONS

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1. NAME AND ADDRESS OF ORGANIZATION

Prof. W. Nozynski
Centralny Osrodek Badawczo-Rozwojowy
Przemyslu Stolarki Budowlanej
Ul. Laskowa 4
05-200 Wolomin
Poland

COLLABORATING ORGANIZATIONS

Dr. W. Dzbenski, Warsaw Agricultural University
Prof. M. Wnuk, Institute of Wood Technology

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

Collaboration with Dr. Dzbenski's projects.

3. OBJECTIVES OF PROJECTS

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4. FURTHER TECHNICAL DETAILS

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5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

Polish standard PN-81/D-03150: Timber structures, design rules. Design is based on the limit states and partial safety factors for loads and materials.

6. REFERENCES

None.

7. OTHER QUESTIONS

--

1. NAME AND ADDRESS OF ORGANIZATION

Prof. B. Thunell
Royal Institute of Technology
Wood Technology and Processing
S-10044 Stockholm
Sweden

COLLABORATING ORGANIZATIONS

--

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

(a) *Tolerances in practical grading, visual and by machine; their influence on permissible stresses and relation to grading conditions (species, speed, light, etc.).*

(b) *International unification of stress grading rules.*

(c) *Grading rules for special uses such as glulam.*

3. OBJECTIVES OF PROJECTS

See 2 above.

4. FURTHER TECHNICAL DETAILS

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5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

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6. REFERENCES

Reports from Swedish Forest Products Research Laboratory, Royal Institute of Technology.

Svensk Byggnorm 80 (The Swedish Building Code).

7. OTHER QUESTIONS

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1. NAME AND ADDRESS OF ORGANIZATION

Dr. Jozsef Bodig
Prof. of Wood Science and Civil Engineering
Department of Forest and Wood Sciences
Colorado State University
Fort Collins, Colorado 80523
U. S. A.

COLLABORATING ORGANIZATIONS

Mr. R. A. Sa'Ribeiro, Forest Products Research Centre, Manaus, Brazil.
Mr. C. D. S. Lisboa, Institute for Forest Development, Brazil.
Mr. R. Mutuku, University of Nairobi, Kenya.
Mr. R. D. Sotelo, Lacitema, Mexico
Mr. G. Somfalvi, University of Forestry and Wood Technology, Hungary.

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

Two projects with implications for lumber grading:

(a) Reliability - based design of wood transmission pole structures.

(b) Tensile strength of wood containing defects.

3. OBJECTIVES OF PROJECTS

(a) To develop a reliability-based design procedure for wood transmission structures.

(b) To develop a mathematical model to predict the strength and stiffness of wood in tension containing cross-grain, knots and checks.

4. FURTHER TECHNICAL DETAILS

(a) The project on reliability-based design is both fundamental and applied.

(b) The tension project is a fundamental study.

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

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6. REFERENCES

Bodig, J. and Troxell, H.E.: Mechanical Stress-rating of Engelmann spruce.

Bodig, J.: Comments on the mechanical stress-rating of Western Canadian species.

11 References provided.

7. OTHER QUESTIONS

--

1. NAME AND ADDRESS OF ORGANIZATION

Prof. Dr. R. Babicki
General Director
Instytut Technologiidrwena
UI Slowackiego 35
60-824 Poznan
Poland

COLLABORATING ORGANIZATIONS

Mr. Saarelainen, Forest Products Laboratory, Finland
Prof. A. M. Borovikov, Centralnyj Naucno-Issledovatel' skij Institut Mechaniceskoj Obrabotki Drevesiny, Archangels

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

Cooperation in EEC and Finnish project 'Strength indices of construction sawn timber, effect of defects on these indices and mechanized strength classification of sawn timber'.

Own projects:

(1) Testing of prototype device for mechanical strength grading of sawn timber (end 1984).

(2) Research on theoretical foundations of mechanical strength grading (end 1984).

(3) Determination of relationship between modulus of elasticity in bending and bending, compressive and tensile strengths of pine sawn timber (end 1984).

(4) Development of standards as a basis of standard subsystem for mechanical strength grading (end 1984).

(5) Investigation of economic relations concerned with the application of mechanical strength grading (end 1983).

(6) Effect of visual characteristics of softwood sawn over 100 mm thick on its strength properties (end 1984).

3. OBJECTIVES OF PROJECTS

Objective to implement mechanical strength grading of sawn timber and obtain an international certificate for mechanical sorter of ITD-DKT-3 type developed at the Institute. Also to create a basis for changes in the standards listed in question 5.

4. FURTHER TECHNICAL DETAILS

Subjects listed under items 1-5 are related to mechanical sawn timber grading based on modulus of elasticity measurements in bending. Investigations 2 and 3 are of a fundamental character.

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

PN-82/D-94021 - Softwood sawn timber graded by means of strength method.

PN-81/D-03150 - Constructions made of wood and wood based material. Statical calculations and desig. Materials

6. REFERENCES

Grzeczynski, T. and Perkitny, J.: Method and device for non-destructive strength grading of constructional sawn timber.

7 References provided.

7. OTHER QUESTIONS

Questionnaire should also contain a question: 'Why mechanical strength grading of sawn timber does not find a proper interest of sawn timber producers and users?'

It seems that one of the reasons is the divergence of results from different authors investigating a relationship between modulus of elasticity and strength. The solution of these problems is the responsibility of science.

1. *NAME AND ADDRESS OF ORGANIZATION*

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Council of Forest Industries of British Columbia
Research and Development Department
735 West 15th Street
N. Vancouver, B.C.
Canada V7M 1T2

COLLABORATING ORGANIZATIONS

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2. *CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.*

No current projects at present. Working closely with FORINTEK on their various lumber projects. Investigations envisaged in 1983. (Details not yet available.)

3. *OBJECTIVES OF PROJECTS*

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4. *FURTHER TECHNICAL DETAILS*

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5. *BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)*

CSA 086 - Code for engineering design in wood (currently being revised and will appear in 1983 in a limit state design format).

Timber frame houses do not have to be designed to CSA 086 but rather to Part 9 of the National Building Code of Canada - A prescriptive code including span tables, etc.

6. *REFERENCES*

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7. *OTHER QUESTIONS*

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1. NAME AND ADDRESS OF ORGANIZATION

Dr. G. B. Walford
Forest Research Institute
Private Bag
Rotorua
New Zealand

COLLABORATING ORGANIZATIONS

Mechanical Timber Graders Association of New Zealand
P. O. Box 549
Rotorua
New Zealand

2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.

(a) In grade evaluation of visually graded Radiata pine (report due June 1983).

(b) Proof test grading (1 man/year - end 1983).

3. OBJECTIVES OF PROJECTS

(1) Determine the properties of Radiata pine when graded and overseas standards (both visually and mechanically).

(2) Monitor the properties of graded timber as they are affected by site, forest management and sawing patterns.

(3) Evaluate proof testing as a grading method.

4. FURTHER TECHNICAL DETAILS

(a) The in-grade approach developed by Borg Madsen has been used in several New Zealand mills.

5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)

NZS 3604 - Standard for light frame timber construction (descriptive code based on deterministic principles).

NZS 3603 - Standard for structural timber design - deterministic. No great enthusiasm in New Zealand for limit states design format.

6. REFERENCES

Proceedings of the Seminar on Stress Graded Timber held in Rotorua, May 1979.

7. OTHER QUESTIONS

Have recently been concerned with removing the restriction on rate of growth from Japanese grading rules. This was successful.

1. NAME AND ADDRESS OF ORGANIZATION
Prof. B. Madsen, P. Eng.
Department of Civil Engin eering
University of British Columbia
2075 Westbrook Mall
Vancouver, B.C.
Canada V6T IW5

COLLABORATING ORGANIZATIONS
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2. CURRENT PROJECTS RELEVANT TO STRESS GRADING, ETC.
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3. OBJECTIVES OF PROJECTS
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4. FURTHER TECHNICAL DETAILS
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5. BUILDING STANDARDS (DEVELOPING COUNTRIES ONLY)
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6. REFERENCES
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7. OTHER QUESTIONS

Important to grade so that the proposed ISO system of strength grades will be followed. Should develop grading rules to obtain stresses in the proposed strength classification system.

United Nations Industrial Development Organization

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*INITIATIVES TO REINTRODUCE TIMBER BRIDGES IN THE UNITED STATES OF AMERICA**

Prepared by

*Richard M. Gutkowski***

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1. U.S. NATIONAL BRIDGE INVENTORY PROCESS

Due to improved technology and marketing opportunity, a strong effort is underway to reintroduce timber bridges in the United States. In general, a concern exists about and governmental efforts are ongoing for the improvement of the condition of bridges of all types and materials. The Federal Highway Administration, in cooperation with the states, has established and been maintaining a National Bridge Inventory (NBI) for the nation's bridges. The NBI provides a common reference for determining replacement/repair needs.

Data in the computerized NBI primarily reflect the outcome of detailed biannual inspections mandated by the 1968 Highway Act. The Manual for Maintenance Inspection of Bridges [1] issued by AASHTO and FHWA in 1970 established the inspection procedures. Each inventoried bridge is assigned a "sufficiency rating" to be used in prioritizing bridge reconstruction needs. The sufficiency rating reflects three considerations in the following relative percentages

Structural Adequacy and Safety	55%
Serviceability and Functional Obsolescence	30%
Essentiality for Public Use	15%
	100%

Higher priorities for replacement/rehabilitation funds are given to bridges with the lower sufficiency ratings. Bridges rated 50 to 80 are eligible for rehabilitation. Those rated below 50 are eligible for replacement. Bridges must have a length greater than 20 ft to qualify for either category. Lists of eligible bridges are compiled by each state. States compete for funds made available through the Federal

Highway Bridge Replacement and Rehabilitation Program (HBRRP). Minimum and maximum limits exist for the percentage of annual federal funds any state may obtain. Legislation also directs that a minimum of 15 percent and a maximum of 35 percent of federally apportioned funds be expended for bridges off the Federal-aid system.

The HBRRP provides funds for replacement or rehabilitation of "structurally deficient" and "functionally obsolete bridges." Structurally deficient bridges include bridges posted for vehicles lighter than designed for, closed or in need of immediate rehabilitation to remain usable. Functionally obsolete bridges have deck geometry, load carrying capacity, clearance or approachway configurations inadequate to safely provide the intended service. Based on assigned sufficiency ratings these bridges are designated as eligible for either replacement or rehabilitation. The early 1983 breakdown of HBRRP eligible bridges (of all types and materials) is:

	Bridges Eligible for Replacement	Bridges Eligible for Rehabilitation	TOTAL
Federal-aid	27,304	35,492	62,796
Off-system	123,698	51,352	175,050

The estimated cost of these replacement/rehabilitation needs is estimated at $48.9 billion. The off-system bridges alone require $22.2 billion.

2. CONDITION OF TIMBER BRIDGES

(a) National Roadways

Global examination of the NBI data indicates a pronounced need exists to upgrade timber bridges on national roadways. As of August 1983, a total of 566,443 bridges had been inventoried with the following results:

	On Federal-Aid System	Off Federal-Aid System	TOTAL
Number of Bridges	262,268	303,175	565,443
Percent of Total	46%	54%	100%
Number of Timber Bridges	9,771	61,428	71,199
Percent of Timber Bridges	14%	86%	100%
Percent of Total	4%	20%	13%

A 1982 Department of Transportation report indicated 76,589 bridges, Federal-Aid System bridges and 129,239 Off-System bridges were constructed before 1940. This constitutes nearly 40 percent of the bridges inventoried at the time. Since these bridges have exceeded realistic service life expectations, many are structurally deficient or functionally obsolete.

The Committee on Timber Bridges of the American Society of Civil Engineers is presently conducting a search of the NBI to establish specific timber bridge needs. Based on the August 1983 breakdown of timber bridge frequency, a reasonable expectation is that 4 percent of the Federal-aid timber bridges (2,500 bridges) and 20 percent of the off-system timber bridges (35,000 bridges) are eligible for reconstruction funds. The search will determine the number eligible for replacement and rehabilitation. In turn, these will be sorted by type of construction and compiled on a state-by-state basis.

(b) U.S. National Forests

The USDA Forest Service (FS) is a significant user of timber bridges for roadways. It maintains over 11,000 road bridges and adds 100-250 bridges to the system annually [3]. About 55 percent have all-timber

superstructures. The number, profile of types of bridges, and use of timber varies considerably between the nine FS regions. Age statistics about these bridges are not compiled, but one casual indicator is the use of contemporary glulam is less than 5 percent in six regions (but 20 percent, 39 percent and 75 percent in the other three regions). Admittedly, unfavorable economics of glulam partially accounts for these statistics. Also, low-volume traffic has contributed to longevity of many bridges. Despite this, FS officials report new or replacement bridges are required at a rate of 270 per year at a cost of $10 million.

A primary contributor to deterioration of FS bridges is an inability to provide regular, thorough maintenance. Lack of budget funds typically places maintenance at low priority and rehabilitation even lower. Service life is considered fulfilled if 30 years of use are realized. Rotted deck laminations, excessive maintenance needs, loss of tightness, impaired load distribution, delamination and asphalt deterioration are major reasons for electing to replace, the first two being the most compelling. Usually, glulam deck is used in "deck only" replacements. However, complete superstructure replacements are typically steel girders with concrete deck. Funding availability, relative condition of troubled bridges, and economics vis-a-vis increased timber haul feasibility are critical elements in the decision process.

Given the inadequacy of annual maintenance funding, the FS is seeking methods to both maximize the service life of their existing and new bridges and still rely on timber as a major material. Field evaluation of in-place bridges; examination of national maintenance rehabilitation and repair (MRR) needs, and technology transfer are key

directives in the process. Abandonment has seldom been an option with reposting or redefining the use of the accessed land being preferred. On logging access roads, completion of or discontinuation of logging typically renders bridges completely safe for remaining traffic.

3. INSPECTION, MAINTENANCE, REHABILITATION AND REPAIR ACTIVITY

(a) Inspection of Experimental Bridges

In the summer of 1983, the author served as the leader of a unique inspection study made of 18 experimental timber bridges in the U.S. National Forests. Constructed in the late 1960's and early 1970's in coordination with the U.S. Forest Products Laboratory, the various timber bridges contained special features expected to improve performance. The bridges were built in various national forests in seven states and varied in length from 20 to 168 feet (20- to 73-ft individual spans). The number of spans ranged from one to four. Primarily, they were constructed (or reconstructed) with transverse glued-laminated (glulam) panel decks and a variety of interpanel connections. Some bridges had either existing or new nail-laminated (nail-lam) decks for comparative purposes. Different types of members, construction and materials were used in the remainder of the superstructure and substructure. The two-fold objective of the study was: (1) to assess the in-place performance of timber bridges, and (2) to examine patterns of moisture content in order to assess the merits of dry-use versus wet-use design stresses. Extensive and detailed results have been reported [7] and will be published [9].

Overall, the inspected bridges were in excellent structural condition. Typically, roadway conditions were excellent, providing for

smooth passage regardless of surfacing. There was extensive asphalt cracking only where the surface was unusually thin. Evidence of deterioration either due to propagation of cracks or presence of potholes was rare. Dowel-connected deck panels were tightly mated.

In these bridges, glulam decks generally provided a more effective roof over stringers than nail-lam decks but both types had high moisture content. In contrast, the stringers were relatively dry. On average, about 100 moisture content readings (electrical resistance meter) were taken per bridge. Stringer readings in excess of 20 percent were infrequent but the average moisture content in both decking types exceeded 20 percent. For bottom zones of stringers, the moisture content was and would likely remain well below 20 percent. Readings above 30 percent were rare in all components except nail-lam deck. The observations about moisture content strongly suggested modern timber bridges components remain below fiber saturation condition for at least 20 years.

Bottom laminations of glulam stringers had moisture content in range acceptable for use of dry-use allowable stresses. Readings between 13 percent and 15 percent were the norm for glulam and although occasional values above 16 percent were found, the soundness of the material appeared invariant. Except near abutment, dry-use stresses for top laminations were found to be similarly justified. Dry-use stresses for solid-sawn timber were also supported by the findings in this study. Virtually all readings were at or below 19 percent, including in the abutment zone. Conversely, the observations did not support the application of dry-use stresses to any decking regardless of treatment method. As a consequence of these findings, the American Institute of Timber

Construction (AITC) now recommends wet-use stresses for all glulam decks, regardless of treatment type, and dry-use stresses for stringers.

(b) Maintenance, Rehabilitation and Repair (MRR)

During the summer of 1984, the feasibility of rehabilitating nail-lam timber decks was investigated by interviewing FS bridge engineers in the nine FS regions and reviewing available technical literature. Statistics cited in Section 2(b) are extracted from a report on that study [8]. The survey revealed the extent of the needs together with current practices and constraints. The literature survey included an evaluation of technology of potential use to the nail-lam deck MRR needs.

A promising technology, developed in Ontario, Canada, was identified as a potential means of restoring old nail-lam decks by post-tensioning and prestressing new decks [10]. To date the method has been implemented only on longitudinal nail-lam deck bridges for which it was specifically developed, but it may be applicable to transverse decks also. The fundamental concept is promising; however, there are concerns about loss of pretension, need for periodic retightening, effects of humidity, and initial costs. Also, the variety of timber constructions identified as existing in the FS is exhaustive. Inventories of the individual regions differ considerably as do the inherent MRR needs. Four prerequisites to developing a needed national MRR initiative were recommended:

1. Computerization of the bridge inventory to put statistics on bridge condition in a common format and identify and clarify needs.

2. Workshops to disseminate information to administrators, engineers, and maintenance personnel.

3. Demonstration projects to display and evaluate new methods and technologies, such as the Ontario prestressing procedure. The Forest Service has several sites which are well suited to such projects.

4. Development of a long-term program modelled after the Ontario Ministry of Transportation's successful efforts to upgrade timber bridges [5].

The Forest Service is proceeding with a long-term program which will include field surveys of current conditions, economic studies, experimental and theoretical development of new rehabilitation concepts, and finally dissemination of the new methods to the appropriate audience. There are plans to demonstrate the post-tensioning concept in the construction (or reconstruction) of five or six bridges on National Forests in fiscal year 1986. In addition a novel truss-framed, prestressed timber bridge will be built in 1986. Arranged like parallel-chord floor trusses, it is hoped to increase longitudinal stiffness and allowable lengths for timber bridges.

4. TECHNOLOGY TRANSFER ACTIVITIES

Discussions between the AITC and the U.S. Forest Service in April 1983, concluded use of timber bridges for replacements on secondary and rural roads could be successfully encouraged with developed timber bridge technology. A fact-finding workshop was convened in Milwaukee, Wisconsin in October 1983, to identify actions needed to implement such technology. Knowledgeable professionals from transportation, wood industry, federal government, bridge component suppliers, and national societies reviewed

current capabilities and provided advice on needs. The workshop concluded that existing and newly available timber bridge technology could play a vital role in addressing the nation's bridge needs. Consequent to this finding, the FS developed an exhaustive Technology Transfer Plan for Timber Bridges. The stated goal of the program is to increase the use of timber bridges ten-fold in five years. Major components of the plan include:

1. Preparation of a Timber Bridge Design and Construction Manual.
2. Documentation of the cost-effectiveness of timber bridges.
3. Devising bridge railing details that meet AASHTO requirements.
4. Dissemination of information, particularly at the local (state and county) level audience.
5. Execution of demonstration projects in the field.
6. Conduct of extensive national publicity activities.

General objectives are:

1. Inform state, county, and township officials, Federal agencies, engineers, and contractors about the advantages of timber for new and replacement bridges on local and secondary roads and federally-owned properties.
2. Provide guidance on the rehabilitation of existing timber bridges.
3. Cooperate with mutually interested organizations and associations to improve the nation's road systems by providing safe, economical timber alternatives for bridge replacement needs.

5. PENNSYLVANIA STANDARD LOW-COST BRIDGES

To address the extensive and worsening bridge problem in their state, the Pennsylvania Department of Transportation (Penn DOT) undertook development of ready-to-use low-cost bridge design standards for small bridges (18-130 ft span range) [4]. Steel, reinforced and prestressed concrete and timber bridges are included. The plans are approved for federally funded projects. Timber bridge plans are categorized into the 18-35 ft and 30-90 ft span ranges [6]. Each set includes and illustrates, step-by-step procedures for preparing a set of bridge plans from the standards. The user completes data assembly sheets and blank plan sheets based on field information, which become the construction plans. During bid preparation, the contractor can opt to build the structures specified in the contract or develop an alternate-type structure from the standards. Incorporation of the standards in Computer Aided Design and Drafting (CADD) is a future goal.

6. RURAL BRIDGE NEEDS

Timber bridge technology and development is particularly important to rural needs across the United States. Past emphasis on the development of the natural Interstate Highway System economically constrained the individual states' highway dollars, rural roads were virtually ignored in comparison to the Interstate System. About 95 percent of pre-1935 rural bridges (particularly the farm-to-market road system) are still in use. The majority are deficient for current-day heavy agricultural demands. Bridges built in the 1920's typically were designed for 2- and 4-ton truck weights and had 16 ft roadway widths. Contemporary grain vehicles carry 20 tons or more. A bridge road with below 24 ft is

now considered deficient. Coincident with this weardown and obsolescence, the abandonment (legal and physical) of more than 45,000 miles of railway since 1940 has gradually, but significantly, placed greater demand on the rural system while the in-place bridges have begin to exhaust their service lives.

Rural bridge needs are concentrated in the short- to intermediate-span range. Simple, lightweight, quickly constructed bridges and bridge components are a priority need and of clear advantage in needed MRR and replacement projects. The thrust of the renewed technology for timber bridges in recent and present years is focused on these aspects. Ability to reuse many existing abutments and piers and to incorporate prefabricated stringers and deck panels limits the closure time for vehicle passage. The 1983 Milwaukee workshop concluded production capability existed in sufficient volume, diversity and geographical dispersion to address the material need nationally.

The mandating of a certain range of proportion of the HBRRP funds to off-system bridge needs is perhaps indicative of federal recognition of the severity of the past funding constraints. Increased motor fuel taxes provided by the Surface Transportation Assistance Act of 1982 gave significant additional federal funding for all state transportation activity. Over half the states have since added their own added fuel taxes. A doubling of the research projects reported at the Transportation Research Board from 1982-83 signaled a spurred interest in highway R&D.

A clear market exists in the rural setting for pronounced use of contemporary timber bridges. Extensive use of all timber bridges in the U.S. National Forests has long underscored their capacity for low volume,

heavy-loaded traffic. This is particularly so for roads for access to logging operations where bridges are subject to vehicle weights up to 115 tons. Ongoing technology transfer efforts are intended to convey this capability to state and local (county) bridge officials and, by addressing development needs, enable widespread incorporation of timber bridge elements and structures into their MRR and replacement plans.

7. CONCLUSION

The state-of-the-art of timber bridges in the United States was reported in 1983 [7]. Since that time, documentation of national bridge needs in the United States has brought timber bridges into focus. In rural areas, availability of lightweight, easily erected bridges is essential for improvement of badly deteriorated low-volume secondary roads. In particular, bridges adequate for passage of trucks heavily loaded with agricultural goods is vitally important. Current activity by the timber bridge community centers on establishing and promoting the proven durability and longevity of contemporary timber bridges in such environments.

Efforts are under way to insure widespread use of timber bridge components and standardized systems in a major rehabilitation/replacement program to upgrade the national road systems. Research and development is under way to provide improved components and novel bridge systems having the economics and simplicity needed for rural roads.

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